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**MONTANA DEPARTMENT OF TRANSPORTATION**  
**Environmental Services**

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**Memorandum**

Distribution

**From:** Eric Stimson  
Environmental Services Bureau

Dec. 28, 2004

**Subject:** Final Report: Snowplow Sidecast Experiment, Lewistown Airport Facility

On December 8, 2003, the "Snowplow Sidecast" experiment took place at the old Lewistown airport facility, near the MDT Lewistown Area maintenance division headquarters. This experiment was conducted for the purpose of discovering how much road sand is plowed off the road surface by a snowplow during winter snow plowing operations, and how far from the edge of the road that sand is carried by the plowed snow. This information is important to know when estimating the amount of road sand that is delivered to a river or stream that parallels a roadway receiving winter maintenance operations.

This experiment was designed jointly by the MDT Environmental Services Bureau and by personnel from the MDT Lewistown Maintenance Area, with assistance from MDT Maintenance headquarters personnel, the Montana Office of Public Instruction, and the Western Transportation Institute.

**Experiment Design and Procedure**

**Test Track** A test track for the experiment was prepared on a paved portion of the Montana Driver Education Facility at the old Lewistown Airport. Since part of the experiment sought to understand the role of plowing speeds on the distance that snow/sand is cast during snowplowing operations, collection mats were laid out for snowplowing at 25 mph, 35 mph, and 45 mph (see Figure 1). Strips of plastic artificial grass were cut and installed for the sand collection mats, each mat measuring 3' wide by 10' long. The mats were placed end-to-end, out to a total composite distance of 60' from the edge of the plowed roadway. (After the experiment, it was found that no snow/sand landed farther than 30' from the roadway edge, so Figure 1 shows only the plastic collection mats out to 30'.)

**Crosswind Effects** To accommodate the effects of crosswinds on the experimental data, collection strips were set out on both sides of the roadway, which was plowed going both directions. The results from both collection strips for each of the three speeds were combined and averaged, eliminating the crosswind factor. Once the test track was prepared (see below), the snowplow accelerated northbound to 45 mph and plowed the roadway adjacent to the "45 mph" collection strip, then decelerated to 35 mph adjacent to the "35 mph" strip, then decelerated again to 25 mph adjacent to the "25 mph" strip. The plow then continued on, turned around, accelerated southbound to 45 mph and repeated the procedure going in the opposite direction.

**Track Preparation** In order to compare the amount of sand measured on the collection mats with a total amount of sand, a known amount of sand (in pounds per square yard) was applied to the entire test track surrounding all the collection mats. To establish that known amount, the sand-spreading mechanism (on the same snowplow that would be used in the experiment) was

calibrated before the experiment in the following way: An area measuring three feet in the direction of travel by twelve feet wide (one traffic-lane width) was marked on the pavement (an area containing four square yards). The sand-delivery mechanism was set to the same setting that would be used during the experiment, and road sand was applied to the roadway by the snowplow traveling at 35 mph. The sand that landed on the 3' by 12' area was then swept up and weighed. This procedure was done four times and an average weight was determined for the four passes. This average weight was divided by four to arrive at the average amount of sand applied per square yard to the test track. When the experiment took place, the same application speed and settings and were used to spread sand on the track, resulting in a sand application rate of 2.12 pounds per square yard.

Plowing Procedure When a snowstorm dropped two to three inches of snow on the test track on the morning of December 8, 2003, the experiment took place. The snowplow drove over the track several times (with the snowplow blade up) to make a snowpacked roadway. At 10:05 AM, the snowplow applied sand to the track at the pre-measured rate of 2.12 pounds per square yard. At 10:45 AM, the track was plowed twice in each direction, at the three speeds described above. At 12:16 PM, the track was plowed a third time in both directions, resulting in a roadway with very little snow left on it. At 12:21 PM, the Lewistown maintenance crew began picking up the collection mats.

Collection Mat Handling Before the experiment took place, each 3' by 10' collection mat was dried, marked and weighed along with its dried and marked canvas bag. After the snow/sand was plowed off the test track, each collection mat was picked up and placed in its corresponding canvas bag, taking care not to spill any snow/sand in the process. The bags with the mats inside were sealed and dried, the final drying taking place inside a hot air drier in the Lewistown Maintenance facility's laboratory. When dry, each pre-weighed mat and bag were weighed again, the difference in weight corresponding to the weight of sand that was plowed onto that mat during the experiment. The sand collected by each mat was then emptied onto a pan and sieve analyses were performed to determine the size fractions collected by each mat. (The sieve analysis data had not yet been compiled as of the date of this report.)

## Experiment Results

Table 1 summarizes the results of the experiment. It was assumed that each yard of roadway (in the direction of travel) is completely plowed off to the side of the road, and an equivalent one-yard wide area beside the road receives, on average, the amount of sand applied to a yard of roadway. Since the plowed lane is four yards wide (a 12-foot lane), each linear yard of roadway contributes 8.48 pounds of sand (4 times 2.12 pounds per yard) to the collection area.

Of those 8.48 pounds of sand possibly received by the collection mats at each of the six strips of mats (25 mph, 35 mph, and 45 mph, both northbound and southbound), the amount of sand less than 8.48 pounds represents the sand that remained on the test track after the plowing was completed. (MDT's K. Schanz reported that a considerable amount of visible sand remained on the test track after the plowing took place.) Combining the northbound and southbound mats for each speed (bottom set of numbers on Table 1), the following results were observed:

- At 25 mph, 45% of the total sand landed on the closest 10 feet to the edge of pavement, 2% of the sand landed in the area from 10 to 20 feet. The remainder of the sand (53%) remained on the roadway;
- At 35 mph, 15% landed in the area from 0 to 10 feet from the roadway, 1% landed on the area from 10 to 20 feet, with the remaining 84% staying on the roadway; and
- At 45 mph, 6% landed in the nearest 10 feet, 4% landed from 10' to 20', and the remainder (90%) remained on the roadway.

## **Discussion of Results and Conclusions**

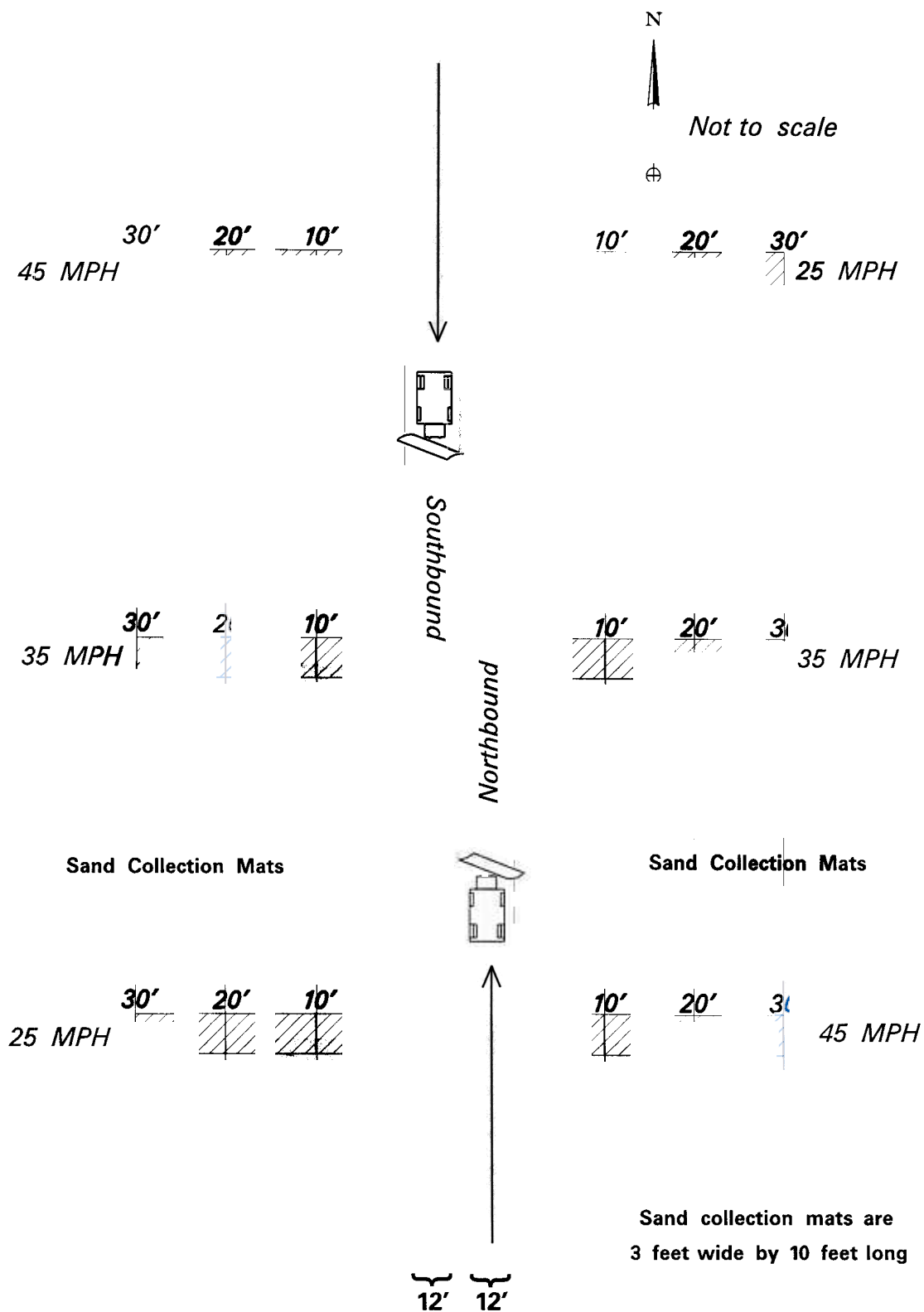
Several conclusions can be drawn from this experiment. However, without repeating the experiment a number of times, all the conclusions are preliminary at this time, to be verified or modified by subsequent repetitions of the experimental procedure. Variables such as air temperature, moisture content of the snow, sand application rate, and the smoothness of the test track may affect the results of the experiment. With this qualification, several preliminary conclusions can be drawn:

- 1 The snow/sand mixture did not travel more than 20 feet from the edge of pavement, with the great majority of the sand landing within ten feet of the edge of the roadway (see Figure 2). That portion of sand remaining on the roadway will ultimately end up on the shoulder after wind and passing vehicles blow it off the pavement. Combining the portion of sand remaining on the roadway with the portion on the 0'-10' strip indicates that over 90% of the sand applied to the roadway will be found on the shoulder area within ten feet of the edge of the plowed pavement. This number will be modified by other forms of erosion or sand transport, but for direct casting of snow/sand by a snowplow, the nearest ten feet appears to be where over 90% of the road sand is deposited.
2. A large proportion of the road sand applied to the roadway remained on the road after the snow was plowed off. Between 53% and 90% of the sand remained on the roadway (or was not accounted for in the sand trapped on the collection mats). This finding is affected by how close to the calibrated sand application rate of 2.12 pounds per square yard the actual application rate was. However, MDT personnel conducting the experiment reported that a large amount of sand was visible on the test track after the snowplowing was completed, indicating that sand remaining on the roadway appears to be a significant factor in determining the fate of traction sand applied during snowplowing operations.
3. The speed of the snowplow during the plowing operation did not significantly affect how far the snow/sand mixture was cast: for all three speeds, over 90% of the sand traveled less than 10 feet from the edge of the roadway.
4. Plowing at slower speeds (25 mph) does a better job of clearing the snow and sand from the snowpacked roadway than at faster speeds (35 mph or 45 mph). This conclusion is reinforced by visual observations by MDT maintenance personnel. The reason appears to be related to the smoothness of the plowed roadway: irregularities such as minor dips and rises in the pavement surface cause the snowplow blade to bounce up in the air, missing some of the snowpack. This bouncing occurs more noticeably at higher speeds, while slower speeds keep the blade in better contact with the pavement surface.

These conclusions, while requiring confirmation by further testing, indicate that the contribution of road sand to adjacent streams by direct snowplow sidecast is minimal when the stream lies 20 feet or more from the edge of the plowed pavement. Higher snowplow speeds do not appear to cause the sand to be thrown significantly farther than plowing at 25 mph. The fact that a large portion of the sand remains within 10 feet of the plowed edge indicates that efforts such as revegetation of the shoulder areas and post-winter sand pickup efforts in the shoulder areas may be effective at keeping sand from leaving the roadway and entering nearby streams.

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MONTANA DEPARTMENT OF TRANSPORTATION

**Figure 1**

**SNOWPLOW SIDECAST EXPERIMENT**  
**Schematic Diagram**

Dec. 28, 2004

MDT Lewistown Maintenance Div.  
OPI Lewistown Facility

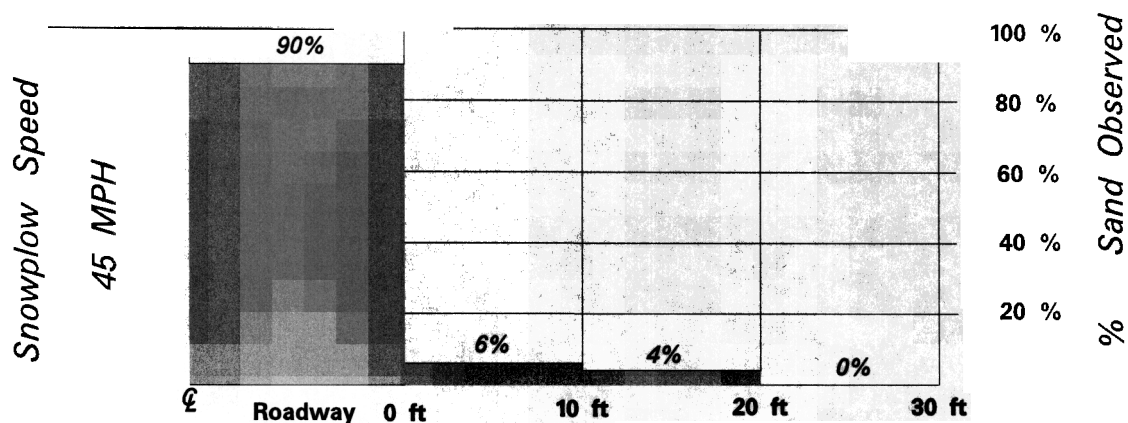
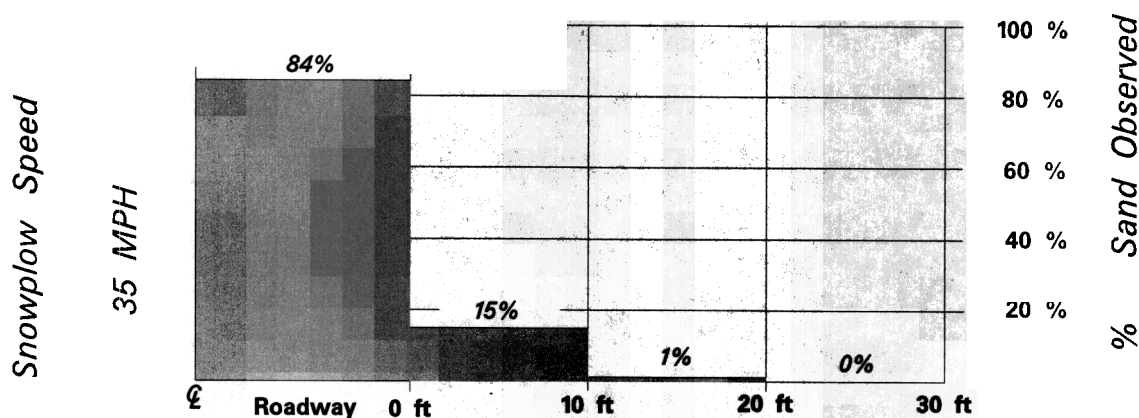
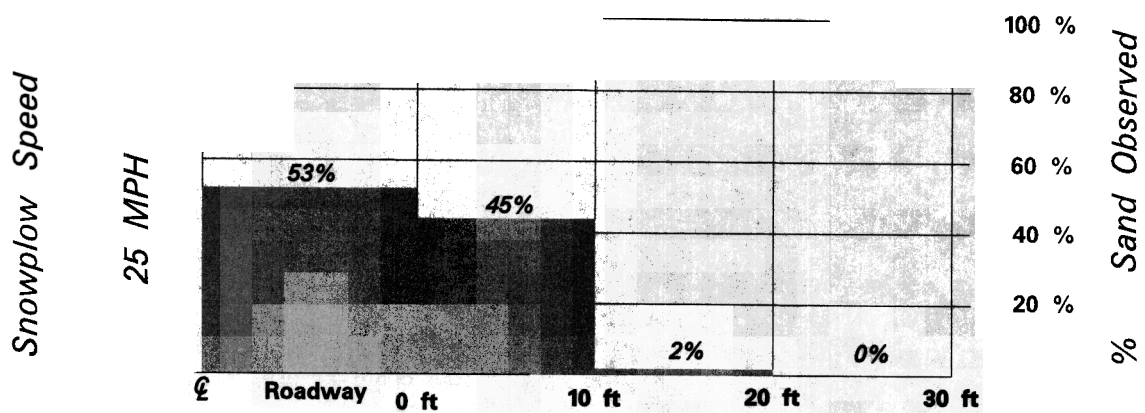
Fergus Co., MT

Table 1

## MDT SNOWPLOW SIDECAST EXPERIMENT

	Total pounds of sand (1)	Pounds sand left on road (2)	lb sand 0'-10' (3)	lb sand 10'-20' (3)	lb sand 20'-30' (3)		% left on road	% cast 0' to 10'	% cast 10' to 20'	% cast 20' to 30'
<b>Northbound</b>										
25 mph	8.48	1.647	6.394	0.439	---		19%	76%	5%	---
35 mph	8.48	6.441	1.940	0.099	---		76%	23%	1%	---
45 mph	8.48	7.611	0.627	0.242	---		90%	7%	3%	---
<b>Southbound</b>										
25 mph	8.48	7.286	1.194	---	---		86%	14%	---	---
35 mph	8.48	7.787	0.565	0.128	---		92%	7%	1%	---
45 mph	8.48	7.617	0.438	0.425	---		90%	5%	5%	---
<b>Northbound plus Southbound</b>										
25 mph	16.96	8.933	7.588	0.439	---		53%	45%	2%	---
35 mph	16.96	14.228	2.505	0.227	---		84%	15%	1%	---
45 mph	16.96	15.228	1.065	0.667	---		90%	6%	4%	---

- (1) "Total pounds of sand" is based on a rate of 2.12 lb of road sand applied to each square yard of roadway.  
Each collection mat is 3 feet wide. Assume each 3-foot wide mat receives the amount of sand found on 3 feet of roadway.  
A 3-foot length of a 12-foot wide lane is 4 sq yards and receives 8.48 lb road sand
- (2) "Pounds sand left on road" is 8.48 lb, minus the pounds of sand measured on all the collection mats at that location.
- (3) Weight of sand captured on each collection mat



**Montana Department of Transportation**

**Figure 2**

**Snowplow Sidecast Experiment**

**Sand Quantities Observed on the Roadway and out to 30 Feet Distance**

Dec. 28, 2004

MDT Lewistown Maintenance Division  
OPI Lewistown Facility

Fergus County, Montana

## APPENDIX 1

### Notes on Experimental Procedures and Quantities

MDT's Kenny Schanz estimated that 2.12 pounds of sand per square yard was applied to test track before plowing it off with the snow during the experiment.

To arrive at this estimate, four marked areas, each measuring 1 yard by 4 yards (4 square yards each), were laid out on the test track. Sand was applied by the snowplow (at 35 mph) at the same setting that was used during the experiment. The four areas received sand, which was collected and weighed. The 4 areas received 2.11 lb, 2.03 lb, 1.90 lb, and 2.38 lb, for an average of 2.105 lb per marked area. Each marked area is 4 square yards, so application rate was 0.53 lb per square yard per application. At the time of the experiment, the snowplow made four applications to the test track, resulting in a total sand load of 2.12 pounds of road sand applied to each square yard of the track.

The collection mats measure 3 feet wide by 10 feet long and were laid out end-to-end out to a distance of 30 feet from the plowed lane (see Figure 1). Since the snow and sand from the entire 12-foot wide lane is plowed off by the snowplow, the sand received by a 3-foot wide collection mat is equivalent to the sand received by a 3-foot by 12-foot section of roadway (minus the sand that never leaves the roadway).

A 3-foot by 12-foot section of roadway (4 square yards) receives 8.48 pounds of sand (4 square yards times 2.12 pounds per square yard). If the sand measured on the collection mat were to add up to 8.48 pounds, 100% of the road sand would be accounted for on the mat. Anything less than 8.48 pounds represents sand that remains on the roadway that was not plowed off during the experiment.

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## APPENDIX 2

### MATERIALS AND PROCEDURES

#### Materials

540 sq ft of plastic “grass mat”, cut into 18 strips, each measuring 3’ x 10’ (30 sq ft);

72 asphalt nails (1 for each corner of the 60 grass strips);

Enough used metal signs to cover all the mats until the time to run the experiment; and

18 cloth bags, big enough to put in a 3’ x 10’ “grass” strip with its snow-sand load on it.

#### Data Collection Procedures

Weigh each 3’ x 10’ grass strip (“sand collection mat”) along with its cloth bag. Label each bag and corresponding strip (e.g. “Northbound, 45 mph, 0-10 ft”) and record the dry, “unloaded” weight of the bag and collection mat.

Nail each 3’ x 10’ collection mat to the pavement, perpendicular to the roadway, end to end, making a composite strip 3’ wide by 30’ long. Repeat for all six test strips.

- After the snowplow has plowed off the snow-sand mixture, collect each 3’ x 10’ mat and put the mat (with its snow-sand load) in its corresponding bag. It is acceptable to wait for some or all of the snow to melt before collecting the mats, providing the snow is not drifting. Efforts were made not to lose any of the sand on the mat when rolling it up and putting it in the bag.

Allow the snow in the bags to melt, then completely dry each bag with its collection mat inside.

- When completely dry, weigh the bag with the collection mat inside. Subtract the “unloaded” weight to get the amount of snow-sand load for each 3’ x 10’ collection mat. Record the sand load for each 3’x10’ strip.

Combine the weights of sand from each “equivalent” 3’ x 10’ collection mat: For example, the northbound 35 mph 20’-30’ strip with the southbound 35 mph 20’-30’ strip), then average the two of them together. (This eliminates the cross-wind factor.)

Tabulate the data.



APPENDIX 3

LEWISTOWN SNOWPLOW EXPERIMENT

DATA RECORDING SHEET

Name: Ken Schanz

Date: Dec. 8, 2003

Time: 10:28 AM

Comments:

2-3 inches of wet snow. Removed plastic. Drive on snow to make snowpack

10:40 AM: Put on sand at 4 passes

10:45 AM: Plow road at 2 passes. 12:16 PM: Made 1 more pass with snowplow

12:21 PM: Started picking up mats. 1st and 2nd pass with plow at mat "C", the  
wind from plow lifted end of mat nearest road.

Weather Conditions

Cloudy, heavy fog

Temperature: 17 degrees F Relative Humidity:

Wind Direction: Calm From the (NA)

Wind Speed Calm